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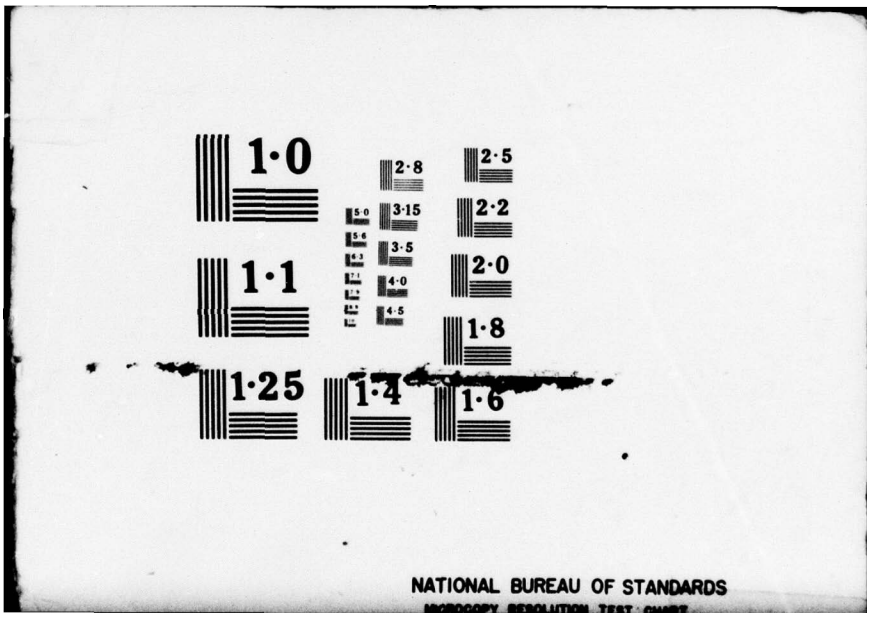
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# AIR FORCE HUMAN RESOURCES LABORATORY



## METHODOLOGY TO ASSESS PSYCHOLOGICAL STRESS AND ITS IMPACT IN THE AIR COMBAT ENVIRONMENT

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*LELAND D. BROKAW, Technical Director*
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Operations within an air combat environment are typically associated with subjective feelings of strain, pressure, and tension. These feelings are referred to as stress and can impact on performance within the combat setting. To identify which pilot operations commonly produce stress, to assess the level of stress generated by those operations, and to evaluate the impact of stress on combat performance, a Combat Stress Questionnaire was developed for administration to combat experienced fighter pilots. A trial administration was conducted using members of the San Antonio Chapter of the Red River Fighter Pilots' Association, and these preliminary findings are presented. Written comments were solicited from these respondents and combined with the preliminary findings; there appear to be indications that while combat per se generates the most severe stress, it is stress experienced prior

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to combat which is associated with performance. Plans for extended data collection and the usefulness of these data to scientific inquiry, training, and the operational environment are discussed. A copy of the Combat Stress Questionnaire is provided in the appendix.

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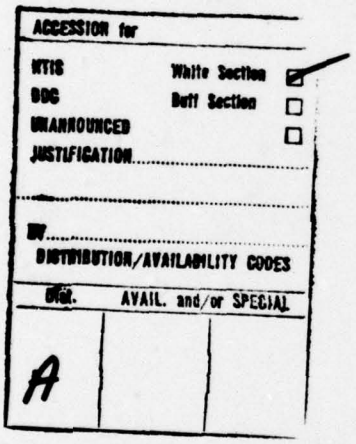
## PREFACE

This research was requested by the USAF School of Aerospace Medicine, Brooks AFB, Texas and conducted under USAD1604, Combat Air Crew Performance. The research was accomplished as a joint effort between the Crew Performance Division, School of Aerospace Medicine, and the Personnel Research Division, Air Force Human Resources Laboratory.

The authors wish to express their appreciation to the membership of the San Antonio Chapter of the Red River Valley Fighter Pilots' Association which readily gave its expertise, cooperation, and enthusiasm.



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# METHODOLOGY TO ASSESS PSYCHOLOGICAL STRESS AND ITS IMPACT IN THE AIR COMBAT ENVIRONMENT

## I. INTRODUCTION

Operations within an air combat environment are typically associated with subjective feelings of strain, pressure, and tension. Research and anecdotal reports indicate that these feelings are common to almost all personnel in combat and are typically not moderated, but rather increase with the individual's length of exposure to the combat setting (Shaffer, 1951). These subjective experiences may be subsumed under the rubric of stress. (Although the term *stress* has been applied to many different phenomena, herein it shall be used to connotate the psychological experiences delineated above.) Previous research on stress has led to one important relationship of particular relevance to performance in air combat; i.e., the more complex the task, the greater the impact resultant from stress (Yerkes-Dodson Law). It would seem reasonable to assume that the task of piloting a high performance jet aircraft to a target, avoiding enemy threat, striking the target, and returning a possibly battle-damaged aircraft to base, would represent a very complex assignment of the type easily disrupted by stress. However, little research has been conducted on the relationship between stress and performance in air combat, and what research is available (e.g., Austin, 1969) has concentrated on physiological indicators of stress rather than directly on the subjective experience and its affects. Therefore, this research was an attempt to deal directly with the issue of the subjective experience of stress and the relationship between that experience and performance in air combat. Specifically, the objective of this research was to develop a methodology capable of (a) identifying which aspects of a typical fighter aircraft mission produce the experience of stress, (b) assessing the level of stress generated by various aspects of a fighter mission, and (c) evaluating the impact of those experiences on performance in the air combat environment. It should be noted that only very preliminary results from a trial study are available. Therefore, it would be best to consider this report as a presentation of the methodology which was developed rather than a presentation of a completed research effort.

## II. METHOD

### Subjects

Subjects were selected from the membership of the Red River Valley Fighter Pilots' Association. Membership in this organization is limited to fighter aircrews who have flown missions into the heavily defended areas in North Vietnam. This geographic region proved to be an intensely hostile air combat arena with enemy threat coming from interceptor aircraft, surface-to-air missiles, and numerous antiaircraft gun emplacements. Therefore, members of this organization have accrued the most recent USAF experience of conducting air operations in a major theater of battle. For the trial study, reported herein, subjects were selected from the local San Antonio Chapter of the Red River Fighter Pilots' Association. A follow-up study, now in progress, will utilize subjects selected on an expanded, national basis.

### Development of the Survey Instrument

To obtain data on stress and its impact on air combat performance, the Combat Stress Questionnaire (Appendix A) was developed. The main body of the questionnaire is a listing of specific events which a pilot might expect to encounter during fighter aircraft missions to heavily defended targets. These events range from cockpit checkout through film assessment and include events which would occur on every mission; e.g., take-off to events which occur with fortunate rarity; e.g., aircraft damage – requiring emergency action. For each item listed, the respondent is asked to make two responses: *first*, to indicate how frequently this event occurred; and *second*, to indicate the stress level of that event. Other information requested on the survey includes how frequently the respondent flew various types of missions (e.g., interdiction), the overall stressfulness of that type of mission, information regarding the respondent's flight experience, and, for various types of missions, an estimate of the number of sorties that could be flown effectively by a single pilot in a 2-week period under the stress levels encountered during missions flown into North Vietnam. Finally, the respondents were asked to provide any additional information which they considered relevant

concerning stress and its affect on combat performance. Administration time for the Combat Stress Questionnaire is estimated to be 15–20 minutes. A copy of the Combat Stress Questionnaire is provided in Appendix A.

### Statistical Procedures

The respondent's indication of the frequency of any event occurring and his estimate of the stress associated with that event were combined to generate an event stress factor. This factor is the product of frequency x stress (coded as per Appendix A). This process produces a stress factor, reflective of both the probability and effect of any particular event and can be averaged with other event stress factors to produce a stress factor associated with a particular phase of a fighter mission. For this study, a mission was divided into eight phases: (a) ground operations, (b) take-off, (c) enroute procedures, (d) mission responsibility, (e) combat operations, (f) + $G_z$ exposure, (g) aircraft damage, and (h) landing. The specific events comprising each mission phase are presented in Figure 1.

Since mission phase stress factors are averages, not affected by the numbers of events per phase, they are comparable and can be used to indicate which phase of a mission is more or less stressful than other phases. To evaluate the impact of stress on performance, a stepwise linear regression analytic approach was used. The dependent variable (criterion) for this analysis was the respondent's estimate of how many missions (only of the specific type which the respondent flew most often) a pilot could fly effectively in 2 weeks under the stress levels encountered in flying missions into North Vietnam. The predictors for this analysis were the mission phase stress factors formed from that subject's responses. Although both predictors and criterion are subjective data, they are appropriate here since the phenomena of stress is a subjective experience. For the trial administration of the Combat Stress Questionnaire, relatively few subjects were obtained, so no further statistical analyses were accomplished; however, when sufficient data have been obtained, a more complete statistical analysis of the data will be possible.

## III. RESULTS AND DISCUSSION

From the trial administration of the Combat Stress Questionnaire, complete data sets were obtained from 16 subjects. Therefore, it should be emphasized that these preliminary results are an example of what can be obtained through this method rather than the product of a completed research effort. The extended application of this methodology to a much larger sample is currently in progress, and it is anticipated that more conclusive results will be forthcoming.

Mission phase stress factors were calculated and are presented in comparative, graphic form in Table 1. It can be seen that combat operations generated the greatest stress factor, followed by exposure to + $G_z$, mission responsibility, enroute procedures, ground operations, aircraft damage, take-off, and finally, landing. Although finding that combat operations produced the greatest stress was not surprising, finding that + $G_z$ exposure produced the next greatest stress was somewhat unanticipated. This might result from a complex interaction between physiology and psychology arising from abnormal strain on the body or the fact that high + $G_z$ maneuvering might occur primarily in the presence of enemy threat. Further research is needed on this point.

To evaluate the relationship between mission phase stress factors and performance, a stepwise linear regression was performed. The results of that analysis are summarized in Table 2. It can be seen from this analysis that only the mission phase stress factor associated with take-off was significantly ($p < .05$) related to the measure of air combat performance. However, given the small sample size used in this trial administration, finding any significant relationship could be interpreted as indicative that the methodology may be useful in researching this area.

Although the relationships between the other mission phase stress factors and the criterion were not statistically significant, it is interesting to consider their entry into the stepwise procedure. From the order of entry, it would appear that stress felt before actual combat begins (firing and/or being fired upon) is more reflective of performance than stress experienced during actual combat. This relationship was partly supported by several of the written comments supplied by the respondents. These comments might be summarized as indicating that the pilot experiences more stress on the way toward the target than over the target. Some respondents indicated that they felt stress only until the aircraft was airborne, then proceeded to feel more and more relaxed as the mission was flown. However, it is not clear at this time whether the relationships found in the trial administration will be representative of those relationships which will be found with the larger national sample.

**Phase I – Ground Operations**

Cockpit Checkout
Engine Start
Taxi
Weapon Armament
Debriefing
Film Assessment

**Phase II – Take-Off**

Day Take-Off, Clear Conditions
Day Take-Off, Instrument Conditions
Night Take-Off, Clear Conditions
Night Take-Off, Instrument Conditions

**Phase III – Enroute Procedures**

Ground Aborts
Air Aborts
Air-Air Refueling
Air-Air Refueling Disconnects
Four Ship Formation Flying
Twelve-Sixteen Ship Formation Flying
POD Formation Flying

**Phase IV – Mission Responsibility**

Flying as Mission Commander
Flying as Flight Commander
Flying as Element Leader
Flying as Wing Man

**Phase V – $G_z$ Exposure**

+ $G_z$ Exposure – 8.5g
+ $G_z$ Exposure – 4.5g
+ $G_z$ Exposure – 2.0g

**Phase VI – Combat Operations**

Air-Air Threat Exposure (ACM) – One Encounter
Air-Air Threat Exposure (ACM) – More than One Encounter
Air-Ground Exposure (ATG) – 6 passes
Air-Ground Exposure (ATG) – 3 passes
Air-Ground Exposure (ATG) – 1 pass
Ground Threat – 80mm, SAM's
Ground Threat – 80mm, 57mm, 37mm
Ground Threat – Small Arms, 37mm
Time Spent on Target (ATA) – 2 minutes
Time Spent on Target (ATA) – 4 minutes
Time Spent on Target (ATA) – 6 minutes

**Phase VII – Damage**

Aircraft Damage – Requiring Emergency Action
Aircraft Damage – Requiring Precautionary Landing
Aircraft Damage – Insufficient Damage to Interrupt Mission

**Phase VIII – Landing**

Landing, Day, Clear
Landing, Day, Instrument Penetration
Landing, Night, Clear
Landing, Night, Instrument Pentration
Barrier Engagement

*Figure 1.* **Events comprising mission phases.**

*Table 1.* **Mission Phase Stress Factors**

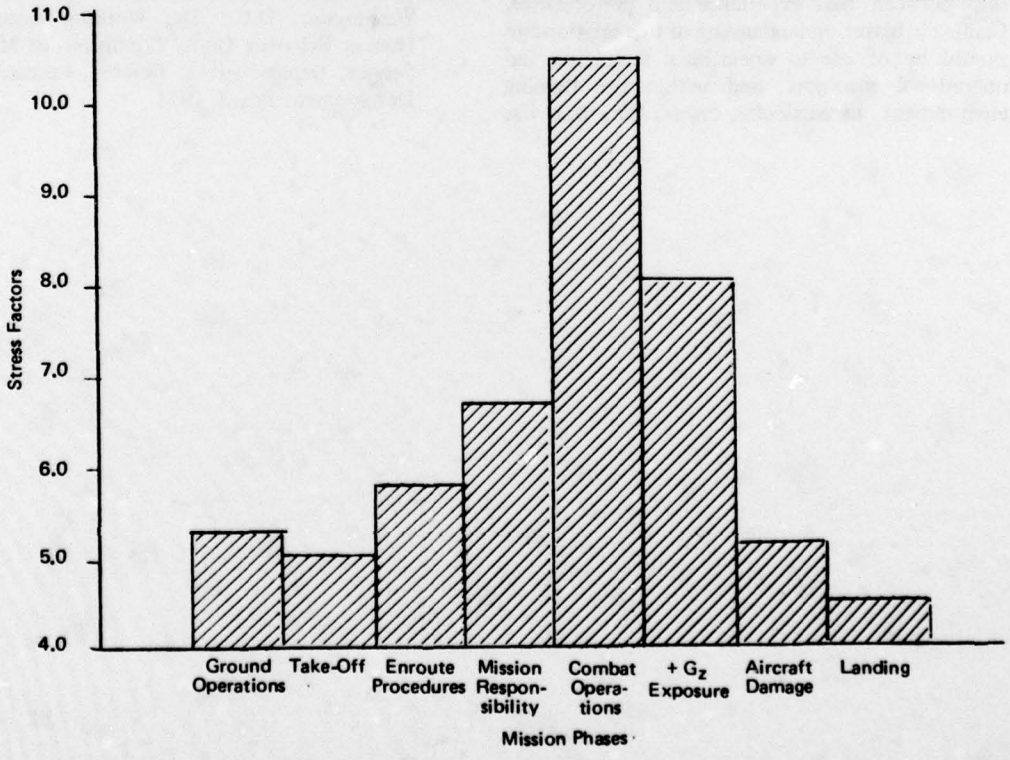

*Table 2.* **Summary of Regression Analysis – Relationship Between Mission Phase Stress Factors and Air Combat Performance [a]**

| Mission Phase[b] | $R^2$ | Change in $R^2$ | Significance Level |
|---|---|---|---|
| Take-Off | .334 | .334 | .019 |
| Ground Operations | .400 | .065 | .256 |
| Mission Responsibility | .512 | .116 | .116 |
| Enroute Procedures | .602 | .086 | .151 |
| + $G_z$ Exposure | .627 | .025 | .431 |
| Aircraft Damage | .643 | .016 | .547 |
| Combat Operations | .669 | .026 | .451 |
| Landing | .671 | .003 | .821 |

[a]Performance being assessed by the number of combat missions a subject would fly.

[b]Listed in order of entry into the stepwise procedure.

## IV. CONCLUSIONS

It would appear from the results of the trial administration of the Combat Stress Questionnaire that this methodology may be useful in evaluating psychological stress in air combat and the relationship between that experience and performance. Gaining a better understanding of this relationship should be of use to operational strategists and operational managers, and within the training environment. In particular, once a data base has been established from combat experienced personnel, similar data might be obtained from participants in simulated combat and comparisons drawn to highlight differences and similarities. It is also possible that as more becomes known about stress, a stress management factor might be introduced into the pilot screening program, either at the point of initial selection or at differentiation into aircraft assignments. However, much research is needed before that point could be reached. In summary, based upon the trial administration of the Combat Stress Questionnaire, it would appear that this methodology will be useful and that there appears to be some quantifiable relationship between the experience of stress and performance within the air combat environment.

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**Shaffer, L.F.** *Fear in combat and its control.* Washington, D.C.: The Working Group on Human Behavior Under Conditions of Military Service, Department of Defense, Research and Development Board, 1951.

## *APPENDIX A.* COMBAT STRESS QUESTIONNAIRE

## COMBAT STRESS QUESTIONNAIRE

The purpose of this questionnaire is to assess the extent and level of stress common to fighter missions in an intense, combat environment. Your past experience makes your opinion relevant to this issue, and your honest cooperation will help ensure valid and useful results.

Stress can be defined as feelings of strain, pressure, or tension. These feelings are common to all personnel operating in a combat situation. Below is a list of events which a pilot might encounter during any one mission. Two responses are required for each event: (1) Frequency of that event and (2) Stressfulness of that event. Rate each on a scale from 1-5 as indicated below, and darken the circle under the response desired. Please base your responses on your experience flying missions to heavily defended targets in North Vietnam.

| "Frequency" | "Stressfulness" |
|---|---|
| 1 - NEVER/ALMOST NEVER | 1 - NO STRESS |
| 2 - LESS THAN HALF THE TIME | 2 - SOME STRESS |
| 3 - ABOUT HALF THE TIME | 3 - MODERATE STRESS |
| 4 - MORE THAN HALF THE TIME | 4 - SEVERE STRESS |
| 5 - ALWAYS/ALMOST ALWAYS | 5 - VERY INTENSE STRESS |

10

| Event | Frequency | | | | | Stressfulness | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 1. Cockpit Checkout | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2. Engine Start | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3. Taxi | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4. Weapon Armament | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5. Day Takeoff, Clear Conditions | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6. Day Takeoff, Instrument Conditions | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7. Night Takeoff, Clear Conditions | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8. Night Takeoff, Instrument Conditions | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Event | Frequency | | | | | Stressfulness | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 9. Ground Aborts | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10. Air Aborts | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11. Air-Air Refueling | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12. Air-Air Refueling Disconnects | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13. Four Ship Formation Flying | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14. Twelve-Sixteen Ship Formation Flying | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15. POD Formation Flying | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16. Flying as Mission Commander | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17. Flying as Flight Commander | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18. Flying as Element Leader | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19. Flying as Wing Man | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20. Air-Air Threat Exposure (ACM)-One Encounter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21. Air-Air Threat Exposure (ACM)-More than One Encounter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22. $+G_z$ Exposure - 8.5g | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23. $+G_z$ Exposure - 4.5g | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24. $+G_z$ Exposure - 2.0g | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25. Air-Ground Exposure (ATG) - 6 passes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26. Air-Ground Exposure (ATG) - 3 passes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27. Air-Ground Exposure (ATG) - 1 pass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Event | Frequency | | | | | Stressfulness | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 28. Ground Threat - 80mm, SAM's | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 29. Ground Threat - 80mm, 57mm, 37mm | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30. Ground Threat - Small Arms, 37mm | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31. Time Spent on Target (ATA) - 2 minutes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 32. Time Spent on Target (ATA) - 4 minutes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 33. Time Spent on Target (ATA) - 6 minutes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 34. AIRCRAFT DAMAGE - Requiring Emergency Action | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 35. AIRCRAFT DAMAGE - Requiring Precautionary Landing | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 36. AIRCRAFT DAMAGE - Insufficient Damage to Interrupt Mission | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 37. Landing, Day, Clear | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 38. Landing, Day, Instrument Penetration | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 39. Landing, Night Clear | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 40. Landing, Night, Instrumentation Pentration | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 41. Barrier Engagement | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 42. Debriefing | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 43. Film Assessment | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

In this section, for each type sortie listed below, indicate how frequently you flew that type of mission, and overall how stressful that type of mission was.

| Event | Frequency | | | | | Stressfulness | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 44. Interdiction | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 45. Ground Support | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 46. Air Cover | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 47. Air-Air Interception | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

In this section, please provide the following information regarding your flight experience.

48. What type aircraft did you fly: F-4 (0) F-105 (0) Other (Specify: ) (0)

49. Rated Experience at Combat Entry: 1-2 years (0) 3-4 years (0) 5-10 years (0) 11 or over (0)

50. Total Fighter Time (hours): 0-800 (0) 801-1500 (0) 1501-2000 (0) 2001-3500 (0) 3501-and over (0)

51. Total Combat Flying Time (hours): 0-100 (0) 101-200 (0) 201-400 (0) 401-and over (0)

For each type sortie listed below, estimate the number of sorties that could be flown effectively by a single pilot in a two-week period under the stress levels encountered in missions flown into North Vietnam.

| Type Sortie | Max. Number in Two Weeks |
|---|---|
| 52. Short Duration (2-3 hours) - Interdiction | |
| 53. Short Duration - Ground Support | |
| 54. Short Duration - Air Cover | |
| 55. Short Duration - Air-Air Interception | |

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